Paper Seminar

Precise measurement of the top quark mass in the lepton+jets topolgy at CDF II



Authors: Florencia Canelli (Fermilab), Jay Hauser, Brian Mohr, Rainer Wallny (UCLA)

Godparents: Young-Kee Kim (chair), Erik Brubaker, Tom Wright (literary)

Reading institutions: Glasgow, Northwestern, OSU, John Hopkins

Paper to be submitted to PRL

March 22, 2007

Documentation

Notes

 CDF note 8361: update with 940pb-1 and with 955 pb-1, CDF Note 8356: validation of the 0i dataset, CDF Note 8038: main, CDF Note 8043: event selection, CDF Note 7716: background probability, CDF Note 7715: transfer function

Web pages

- Internal http://www-cdf.fnal.gov/internal/physics/top/run2mass/MEATv2
 Public 680 pb⁻¹ http://www-cdf.fnal.gov/physics/new/top/2006/mass/ljets_meat_1fb
- Analysis blessed on February 2006 and June 2006
- Godparent committee formed in November 2006: http://www-cdf.fnal.gov/internal/physics/godparents/MEAT



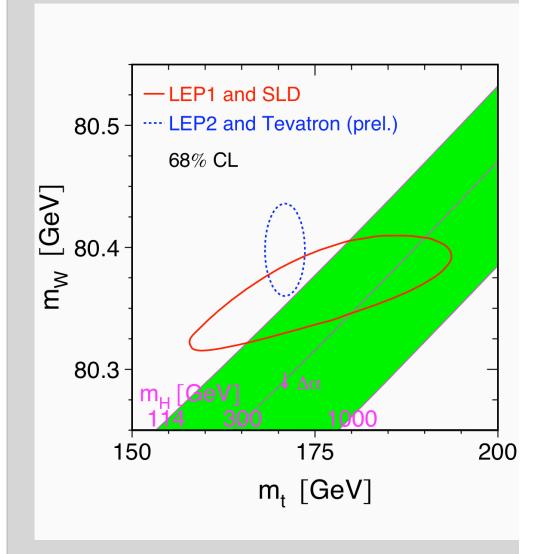
Previous CDF II M_{top} publications

- <u>Top quark mass measurement using the template method in the lepton + jets channel at CDF II</u>, Phys. Rev. D 72, 032003 (2006) (300 pb⁻¹)
- Precision top quark mass measurement in the lepton + jets topology in p anti-p collisions at s^{1/2}=1.96 TeV, Phys. Rev. Lett. 96, 022004 (2006) (300 pb⁻¹)
- Measurement of the top quark mass with the dynamical likelihood method using lepton plus jets events with b-tags in p anti-p collisions at s^{1/2}=1.96 TeV, Phys. Rev. D 73, 092002 (2006) (300 pb⁻¹)
- Top quark mass measurement from dilepton events at CDF II Submitted to PRL (300 pb⁻¹)
- Measurement of the top quark mass using template methods on dilepton events in p anti-p collisions at s^{1/2}=1.96 TeV
 Submitted to PRD (300 pb⁻¹)
- Measurement of the Top Quark Mass in p anti-p Collisions at s**(1/2) = 1.96 TeV using the Decay Length Technique Submitted to PRD (750 pb⁻¹)
- Measurements of the Top-Quark Mass in All-Hadronic Decays in pp Collisions at CDF II Submitted to PRL (300 pb⁻¹)
 - Precision measurement of the top quark mass from dilepton events at CDF II Submitted to PRL (1fb-1)



Precision M_{top} measurements

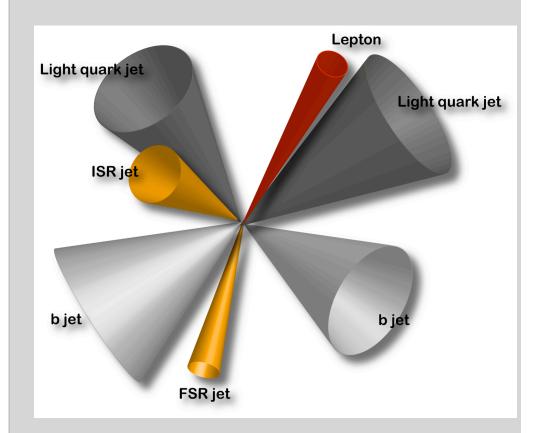
- Allows for prediction of the mass of the Higgs boson
- Constraint on Higgs can point out to physics beyond the standard model
- Consistency checks of the standard model parameters

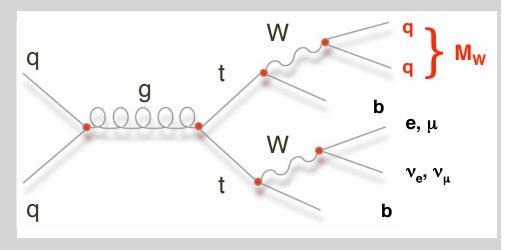




Lepton + Jets

- Final state: one high p_T lepton,
 missing transverse energy, and about
 4 jets
- Good branching fraction (~30%) and high S:B = 1:4 to 11:1 (depending on the number of b-tags)
- Main background: W + jets
- Combinatorial background:12 combinations
- JES can be measured in the same sample (JES in-situ)







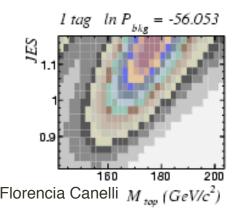
Matrix element analysis

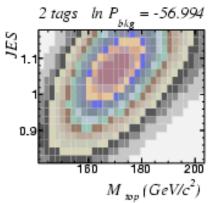
- Technique designed to optimize the use of kinematic and dynamic information
 - Probability for a tt and W+jets hypothesis
 - Integrate over all the unmeasured quantities convoluting the differential cross-section with the experimental resolutions

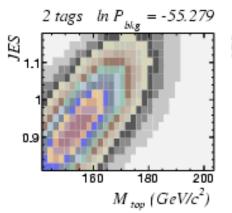
$$\overline{P}(x; M_{top}, JES) = \frac{1}{\sigma} \int d^n \sigma(y; M_{top}) dq_1 dq_2 f(q_1) f(q_2) W(JES, x, y)$$

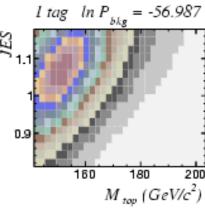
ullet Likelihood used to fit simultaneously $M_{
m top}$, JES, and signal fraction, ${
m C_s}$

$$L(C_s, M_{top}, JES) \propto \prod_{i=1}^{Nevents} (C_s P_{ttbar,i}(M_{top}, JES) + (1 - C_s) P_{W+jets,i}(JES))$$









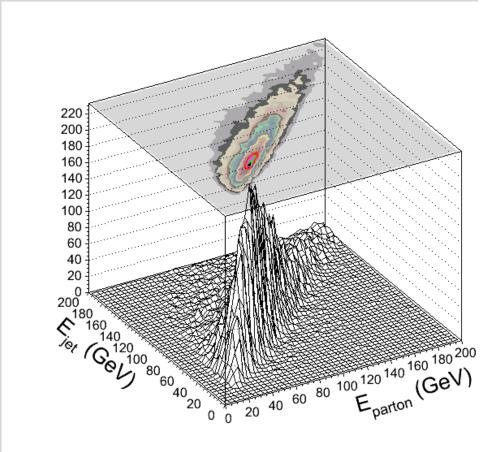
Transfer Functions

Energy of electrons is considered well measured

$$W(JES x, y) = \delta^{3}(p_{e}^{y} - p_{e}^{x}) \prod_{j=1}^{4} W_{jet}(JES E_{j}^{x}, E_{j}^{y}) \prod_{i=1}^{4} \delta^{2}(\Omega_{i}^{y} - \Omega_{i}^{x})$$

Angles are also considered well measured

- Transfer functions W(JES E^x,E^y): model the smearing in jet energies
 - o Use 2 gaussians, one to account for the peak and the other to fit the asymmetric tails
 - o b and light quarks parameterizations





Other parts of the method

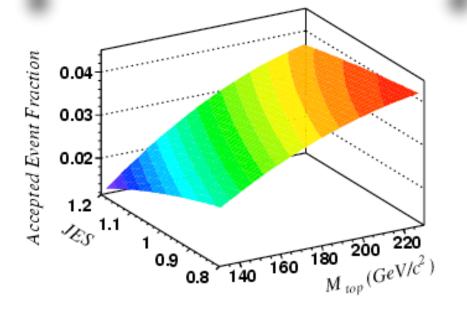
- Pttbar normalization: function of M_{top} taken from the theoretical ttbar cross-section at LO
- Pttbar, PW+jets normalization: relative normalization obtained from MC
- Integrations: P_{tt} VEGAS in pttbar, mt, mtbar, mWhad, mWlep, light parton energy.
 P_{W+iets} MC in energy of partons and mWlep
- 2D grid: calculation of P₊₊ every 2 GeV in Mtop and 0.02 in JES
- Acceptance: enters as part of an extended likelihood. Calculated using MC events with different M_{top} and JES



Event selection

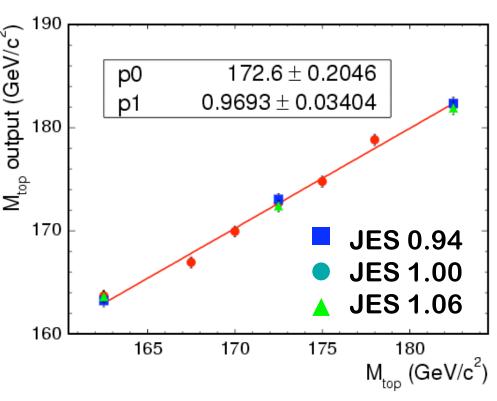
- Central lepton (e or μ) p_T>20 GeV
- Exactly 4 jets with $p_T>15$ GeV, $|\eta|<2$
- Loose jets allowed (8<p_T<15 GeV, any η)
- Missing transverse energy Missing E_T > 20 GeV
- One or more jets with b tagging
- Non-W veto (0.5< $\Delta \phi$ <2.5 when Missing E_T < 30 GeV)

	Expected Events (955 pb ⁻¹)
W+jets (Mistags)	14.5 ± 5.1
Non-W	5.2 ± 2.6
EWK	2.2 ± 0.5
Total background	22.0 ± 16.5
tt (8.0 pb)	145.1 ± 16.5
Data	167





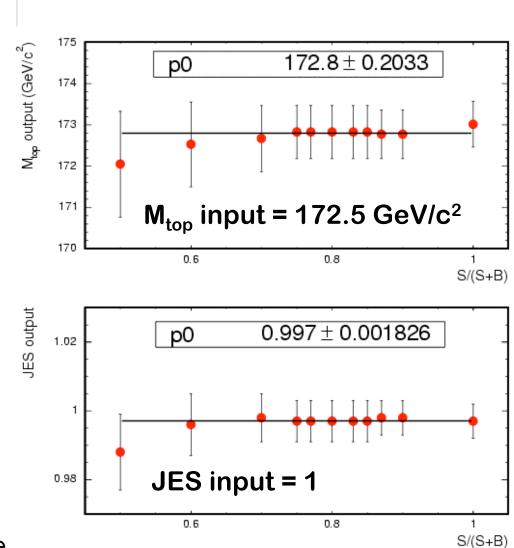
Testing the method with MC



 Output of the method is unbiased for different M_{top} and JES

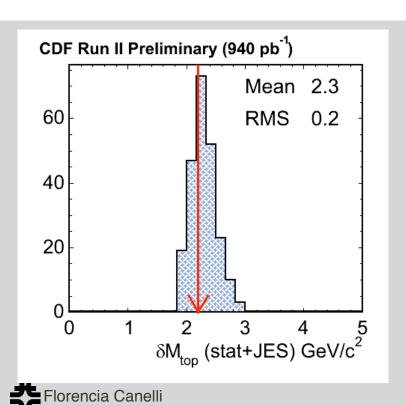
Florencia Canelli

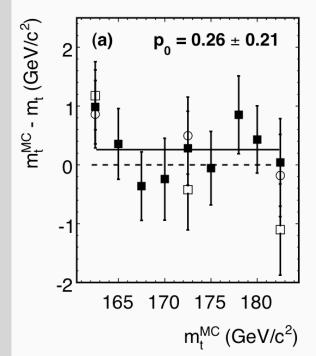
 Adding background events doesn't bias the output M_{top} or JES

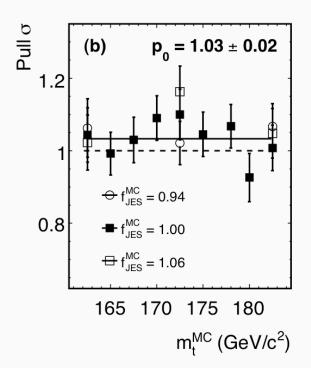


Testing the method with MC

- Pseudo-experiments used: 167 events, with 83% ttbar
- Statistical uncertainty estimation is ok: we inflate it by 3% and add 2% uncertainty as part of the MC syst. uncertainty







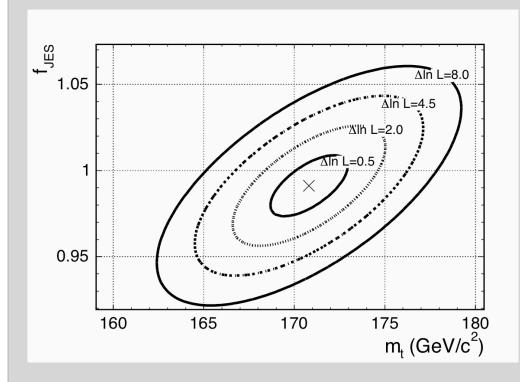
Results

 We used 955 pb⁻¹ and measured with 167 candidates with at least one b-tagged jet

 M_{top} = 170.8 +- 2.2 (stat+JES) +- 1.4 (syst) GeV/c²

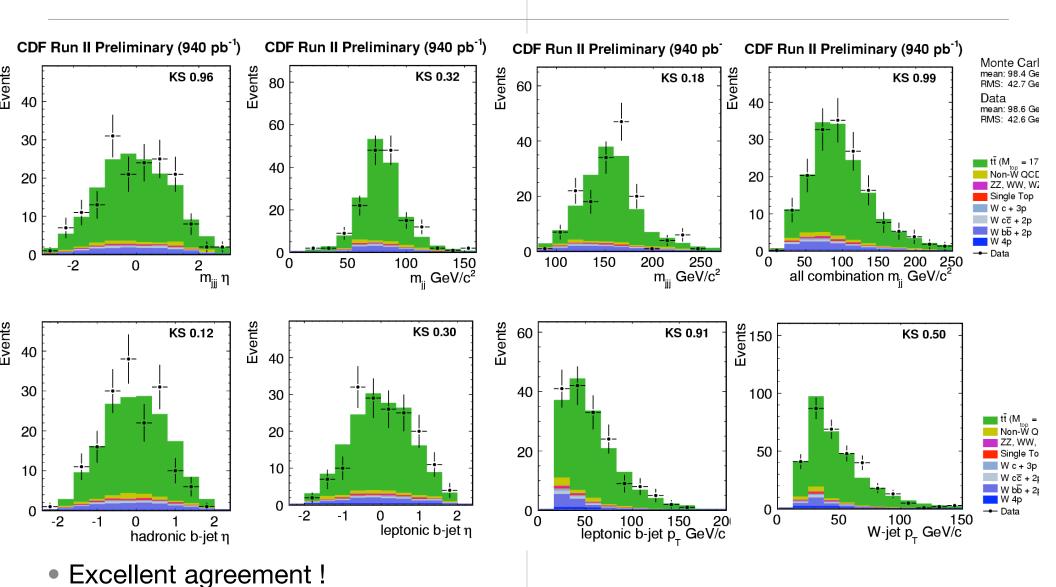
• JES = 0.99 +- 0.02 (stat)

• $C_s = 0.84 +- 0.10 \text{ (stat)}$





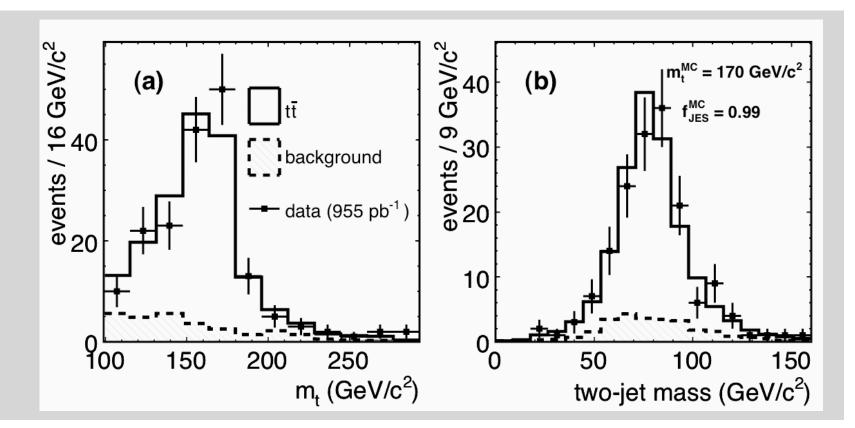
Lepton + Jets data & MC





Lepton + jets data and MC

- Comparison of two kinematic variables for data and MC using JES=0.99 and M_{top}=170 GeV
- (a) Most probable value of M_{top} for each event extracted from evaluating Ptt at JES=1 (b)
 Invariant mass of the pair of jets assigned as W decay products calculated using the most
 probable permutation at the most probable value of M_{top} and JES in each event evaluated
 from Ptt





Systematic uncertainties

Source of uncertainty	Magnitude (GeV/c²)
Initial/Final State Radiation	1.1
Multiple interactions	0.1
Generator	0.2
b-tagging	0.3
b-JES	0.6
JES residual	0.4
Bg composition	0.2
Lepton p _T	0.2
MC statistics	0.2
PDFs	0.1
Total	1.4



Conclusion

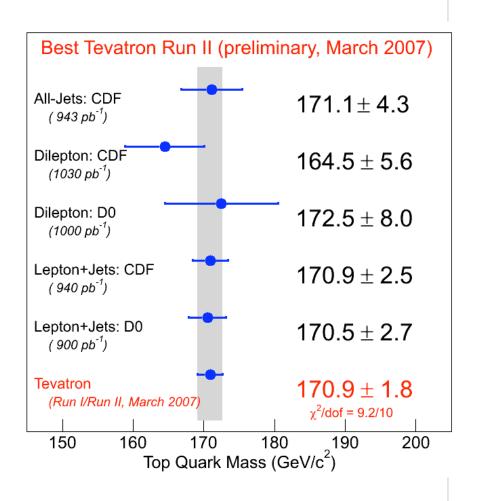
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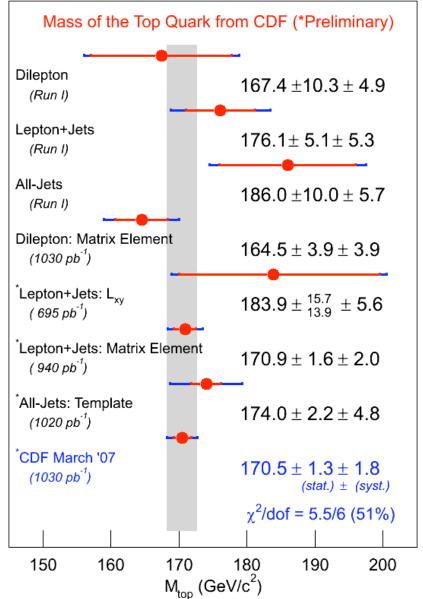
• M_{top} = 170.8 +- 2.2 (stat+JES) +- 1.4 (syst) GeV/c²

- JES 1.5 GeV
- Total uncertainty of 1.5%
- Improvement of 35% with respect to the previous result



Result in March 07 combinations







Thanks from the authors

- Spokespeople: Rob, Jaco, Young-Kee
- Top conveners: Robin, Taka, Evelyn, Kirsten
- Mass conveners: Un-ki, Doug, Daniel
- People running jobs for us
- Reading institutions
- Godparents: Young-Kee, Erik, Tom

